Development of a Next Generation Platform and Instrumentation for Continuous Ocean Observations (PICO) for Reducing the Costs of Observations

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1. Project Summary

The purpose of developing a Platform and Instrumentation for Continuous Observations (PICO) is to advance the state of NOAA's open ocean observation systems with the development of an easy-to-deploy and low-cost mooring system that makes use of novel buoy technology and commercially available sensors and instrumentation (www.pmel.noaa.gov/pico). This Next Generation Climate Observation project is developing low-cost/high quality modular components of moored ocean sensor platforms to enhance and eventually replace the tropical moored arrays that are a cornerstone of the climate observing system.

A new element of this system is the PRAWLER (Profiler + Crawler) mooring development, which will strengthen our moored sampling capability by producing well-resolved vertical profiles (an advance over the present few discrete samples), and adding reliable and routine salinity sampling to the suite of measurements. The sampling is also reconfigurable in real time, allowing adjustment for process studies, responses to storms or marine disasters, and power management. The PRAWLER uses almost no battery power for locomotion and has a heave energy conversion rate of ~80%; that is, for every 1 m of wave heave, the PRAWLER climbs 80 cm. All sampling is done during descent at user-defined intervals and all data is returned in real time. The value is significant cost reductions and improved data that can be made with a single profiling instrument, as opposed to ~12 individual sensors on a mooring line. The smaller mooring is easier and safer to deploy and maintain. These advancements are improving both cost and performance for tropical moorings.

In FY'13 we deployed and maintained two PRAWLER moorings in the subtropical Atlantic as part of the SPURS (Salinity Processes in the Upper Ocean Regional Study; http://SPURS.jpl.nasa.gov/SPURS/) experiment. The systems were deployed in Sept'12 and recovered in Oct '13 and averaged ~ 25 profiles per day and each system made >4000 CTD profiles. Each system also recorded MET: Winds, ATRH, Baro and Rain. We did encounter

some mooring and PRAWLER problems, but do not feel they are significant hurdles towards furthering realtime, profiling CTD platforms that use energy harvesting.

Users of this technology include: 1) ocean and atmospheric researchers and program managers studying ENSO, etc; and 2) scientists and engineers who are evaluating the quality and endurance of the PRAWLER moorings for possible future inclusion in the Tropical Moored Array and commercial viability. We are following the 10 GCOS Climate Monitoring Principles and will complete side-side comparisons with the central WHOI SPURS buoy and ship CTD casts. Users of the data collected during the SPURS experiment are climate researchers, met services, warning and forecast managers, and industry.

2. Scientific and Observing System Accomplishments

This project develops, brings to readiness, and deploys new technology for ocean profiling. The main development in FY'13 was a PRAWLER (Profiler + Crawler) deployment at SPURS that profiled between selectable ocean depths (typically from 3m to 450 m). The PRAWLER presently incorporates a newly commercialized Seabird PRAWLER pumped CTD, but in future years could include a micro-current meter or bio-geochemical sensors such as DO or pH. All sampling is done during (free-falling) descent at user-defined intervals and all data is returned in real time.

a. How did your project deliverables serve the observing system's program deliverables?

   The major advancement made this year is the end-to-end field testing of the PRAWLER hardware and software in a scientific experiment, co-located with other moorings that will enable checking and validation of the technology.

   We exceeded our deliverables and performance measures in the FY'13 workplan by making >8000 CTD profiles (goal:5000) and delivered >90% of the data in realtime (goal:75%). The PRAWLER and buoy technology development serve the climate program deliverables by providing state of the art technology to make high quality, low cost ocean observations. The specific NOAA Climate Goals that are served include:

   - Sea Surface Temperature and Surface Currents
   - Ocean Heat Content and Transport
   - Air-Sea Exchanges of Heat, Momentum, and Fresh Water

   and the specific societal challenges addressed include:

   - Reduce vulnerability to extreme weather (extremes);
   - Prepare for drought and water resource challenges (drought);
   - Manage risks to coastlines and coastal infrastructure (coastal inundation)

b. What did you achieve during FY 2013?

The deliverables for FY 2013 include:
(a) Servicing, operating and recovery of two systems that had been deployed for ~12 months within the SPURS 25°N 38°W area. Data collected include:

a) CTD profiles from 5-450m (typically 8 profiles per day, but up to 20)
b) Wind, AT/RH, Barometer, Rain (hourly)
c) GPS, time (daily)

During the year we had two mooring breaks, but were fortunate to be able to recover and repair them as they parted the mooring line just weeks prior to a scheduled SPURS cruise. We will receive the mooring line in early FY'14 and will investigate the failures, initial indication is fishbite in the first failure and PRAWLER caused abrasion at 3m causing the wire to prematurely corrode and fail.

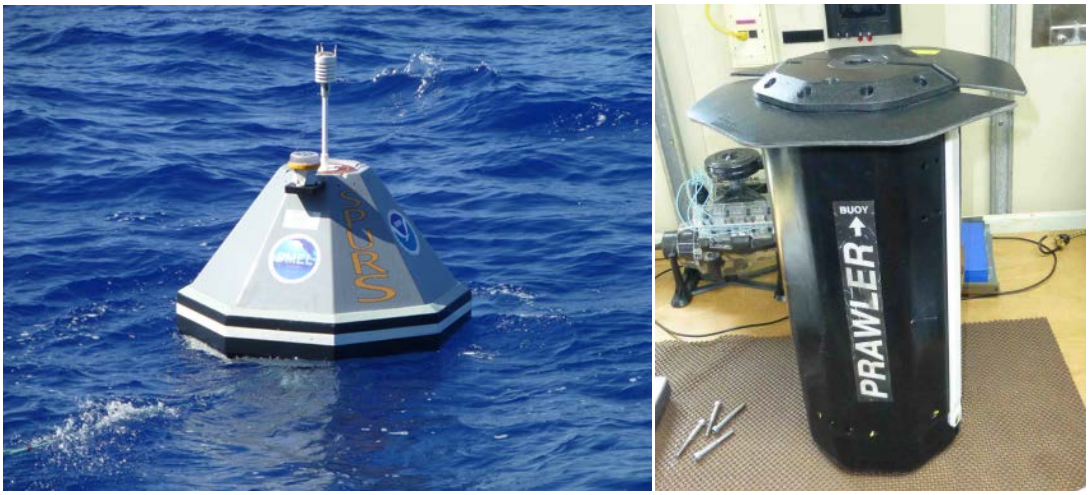

Fig 1: PICO-PRAWLER deployment in SPURS, Sept'12

(b) Complete data comparisons will be done in FY'14, but we were able to make initial plots and comparisons of some of the data. Initial results look very encouraging. For example, the comparison of the two PRAWLERS is shown in Fig 2 showing all uncorrected profiles for the 3 months of operation. Except for one bad profile, the agreement at depth is excellent, showing that the CTDs are producing reliable and consistent salinity values, except for one profile out of 654.

(c) A supplemental proposal was submitted and funded to build and refurbish an additional PRAWLER mooring for comparison with the TAO array. Partial funds were received in June 2013, but an additional buoy was fabricated, all mooring line and sensors were procured. The recovered PRAWLERS from SPURS spring cruise were refurbished and will be qualified in Puget Sound in FY'14 Q1. Based on the success in

SPURS, we are currently investigating ship options to deploy one or two PRAWLERs in the equatorial Pacific by Q4 of FY14, co-located with existing TAO moorings, to evaluate their use in the Tropical Pacific Observing System.

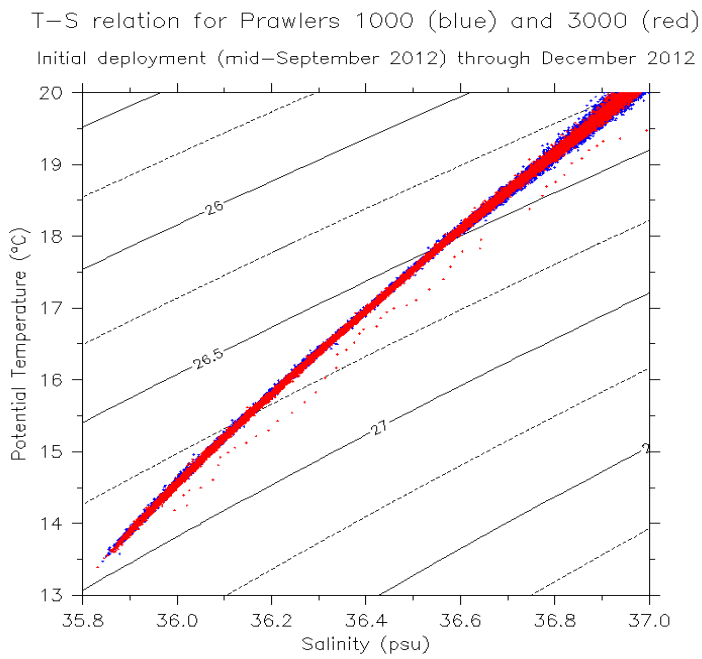

Fig 2: Mean T-S relation between two SPURS PRAWLERs
Underlying (black) contours are sigmatheta (density)

c. What scientific advances were made and/or facilitated through your activities?

The key advance made this year is the real-world, end-to-end testing of the PRAWLER hardware and software in a scientific experiment, co-located with other moorings that will enable checking and validation of the technology. A preliminary look at the data demonstrates the value of the finely-resolved PRAWLER profiles. The year-long mission shows the complexity of the seasonal transitions in the subtropical Atlantic, and the usefulness of the PRAWLER's high resolution both vertically and in time. Figure 3 shows the mixed layer increases from about 60m in late summer to near 100m in December. Significant rainfall beginning in mid-December freshens the mixed layer, but a high-salinity "barrier layer" remains near 100m during late December into January. In this period the mixing is controlled by salinity, not just temperature. This is surprising in this region and will be a topic of research in SPURS.

Figure 4 shows a thinning trend of the deep winter mixed layer during April-June (as expected with weakening winds) was interrupted by an abrupt event in late May. This is seen especially in salinity but also temperature. As there were no major wind events during this period, it is almost certainly due to advection, which will be investigated when we have the central SPURS WHOI buoy current meter data.

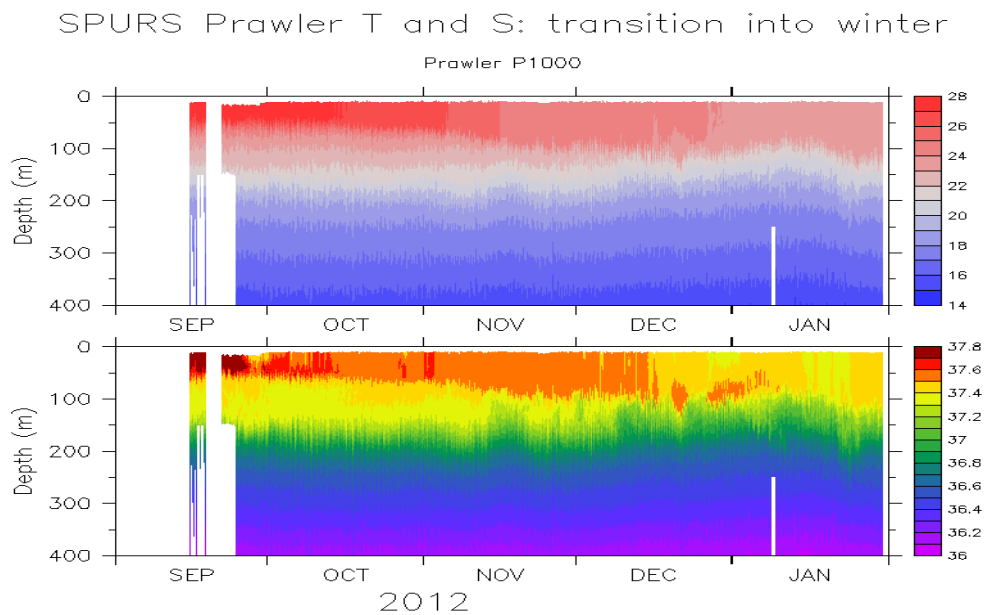

Fig 3: PRAWLER Temperature (top) and salinity (bottom) during the transition into winter.

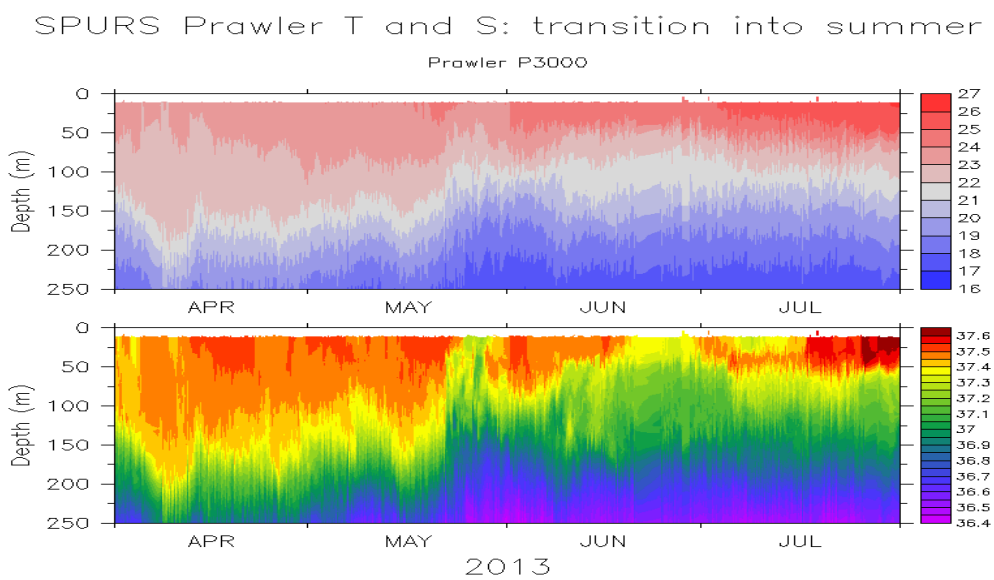

Fig 4: PRAWLER Temperature (top) and salinity (bottom) during the transition into summer.

d. What is the significance of these advances?

We have shown a proof of concept of this alternative and complimentary technology that is much more cost effective than traditional Tropical Moored Buoys. CTD profiles offer researchers an adaptive profiling tool rather than a few fixed discrete-level measurements as are now used on TAO moorings. The present SPURS dataset will be compared with

WHOI mooring discrete sensors and shipboard CTDs and will provide insight on the performance and value of the PRAWLER.

Additionally MET comparisons will allow an evaluation of the ability to make accurate met measurements from a very small buoy. Figure 5 shows a representative sample comparing MET data to subsurface data recorded by the PRAWLER. The top panel includes rain rate from both PRAWLERs (black and red), and the WHOI SPURS mooring (green). They agree well on the timing of rain events, and also with the BP lows (continuous black curve above). Local rainfall is NOT very well linked with the strong near-surface salinity variability: The large freshening in late May occurs with rain, but that is not different than the general rainfall since mid-April. Also, it extends too deep to be locally forced.

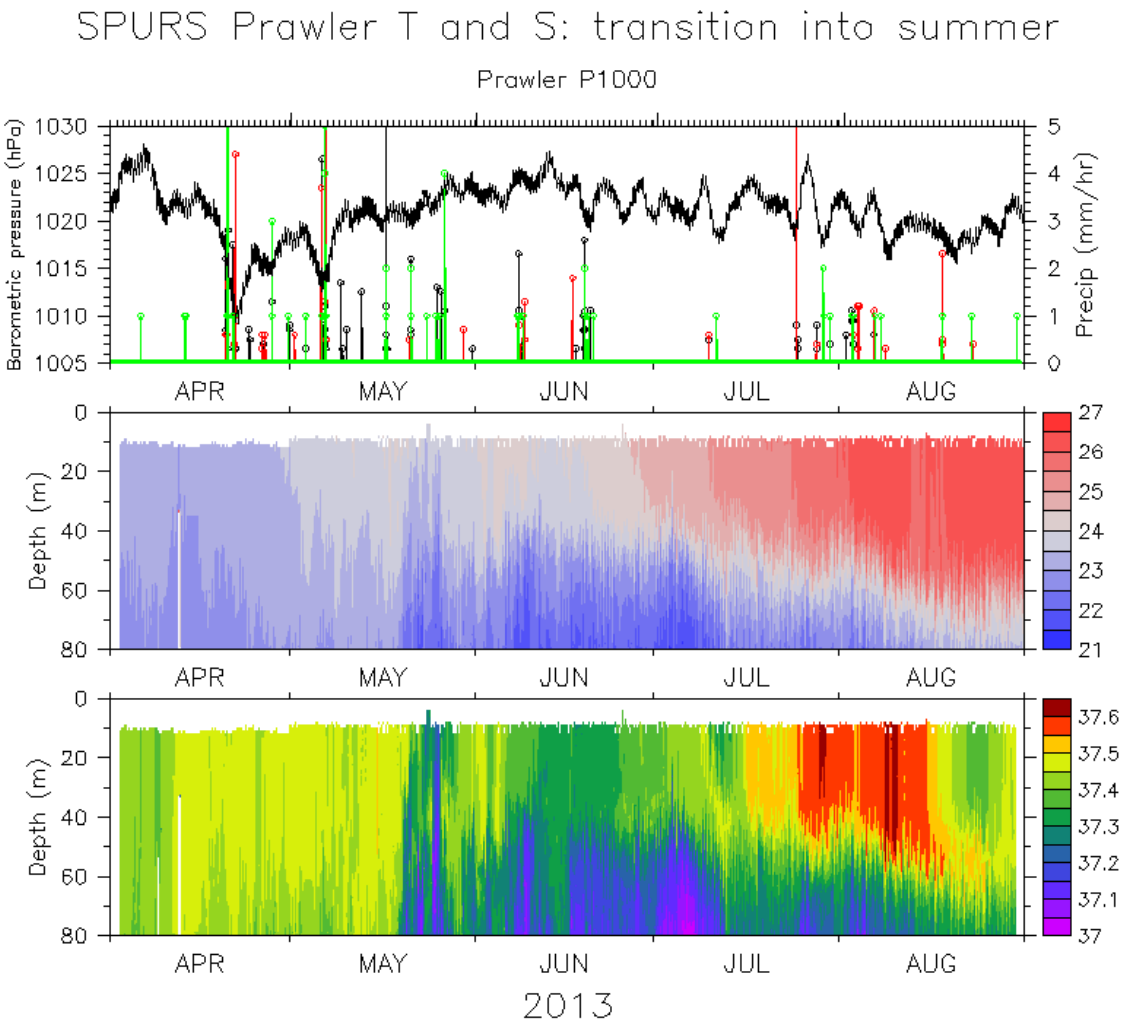

Fig 5: The top panel includes rain rate from both PRAWLER moorings (black and red), and the WHOI mooring (green). T&S show from PRAWLER in bottom panel.

e. What, if any, information was jeopardized due to a lack of funding, lack of instrumentation, or inability to carry out the work?

   Because of the delay and reduction of funding, systems designated for TAO central Pacific testing were not procured until late in the year and we will have to rely on refurbishing the SPURS PRAWLERs and have few spares.

   Also, additional tests on the complete 'easy-to-deploy' PICO system have been delayed until additional funding is available. The all in one, easy to deploy system is the ultimate goal to provide a flexible and low-cost Tropical Moored Buoy to the oceanographic community.

f. What is the web site for your program?

   www.pmel.noaa.gov/pico. Data from SPURS is currently being evaluated by Dr. Billy Kessler on an internal server at PMEL and is being compared with shipboard CTDs and with each other. However, the WHOI SPURS subsurface data is not available in realtime, so those comparisons will be completed in FY'14.

For projects involved with data collection, please address the following questions:

a. Are your data distributed in real time on the Global Telecommunications System?

   As this is a technology development project, the data are not distributed in realtime via the GTS.

b. Where do your real time data reside? Are the data available online?

   The data are available in realtime on an internal PMEL server and are currently being compared to ship-based Underway CTD and shipboard CTD profiles that were taken during the SPURS cruises.

c. Where do your delayed mode data reside? Are the data available online? What is the date of the most recent data available publicly?

   In case of telecoms failure all data are backed up on-board the PRAWLER and will be evaluated once the systems are recovered. PRAWLER data will be shared via the SPURS website and made publicly available.

d. Where are your data archived and with what frequency?
   N/A

e. What is the web site where the data for your program can be accessed? If you haven't updated your web site recently, please do so now.

   http://ferret.pmel.noaa.gov/spurs/UI.vm

f. Have you successfully retrieved your program's data from the website or Data Assembly Center where your data reside, just to ensure the accessibility of the data?

   N/A

g. Do you have a data management plan for the data collected as part of your project? If so, list the url where the data management plan can be found.

   N/A

3. Outreach and Education

Education and outreach was primarily accomplished thru an updated website www.pmel.noaa.gov/pico and thru PMEL Engineering Buoy YouTube channel: http://www.youtube.com/playlist?list=PLE575643A95F6CED2&feature=plcp

Results from this work were briefed by Chris Meinig to eight House and Senate offices as part of the 'OAR Science Days' presentations in May 2013. A 'Science Days' presentation on buoy technology was presented in Silver Spring and well received. PRAWLER developments were also presented at the DBCP annual meeting in Paris, Sept '13.

International collaborations included outreach and training to Japanese, Indian and Australian engineers and scientists. Additionally ~10 tours and a NOAA WRC Open House were given to the general public highlighting NOAA developed technology, including PICO and PRAWLER.

4. Publications and Reports

There were no peer-review publications during this reporting period.